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PHYSIOGRAPHIC NOTES FROM THE UNIVERSITY OF WESTERN AUSTRALIA.

No. II.—EVIDENCES OF UPLIFT IN THE NEIGHBOURHOOD OF PERTH.

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(*Read 9th September*, 1919.)

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Introduction.

The fact of a recent relative uplift of the coastline has been recognised in many places on the Western Australian coast. Uplift has been shown in Western Australia from the Great Australian Bight round the coast to Broome. Apparently the uplift has in

no case been the subject of careful measurement, but it seems to be of the same order as that indicated in the present paper for the Perth area.

The bibliography of the subject is given in Jutson, J. T., Physiography, Bull. No. 61, Geol. Surv. of W.A., p. 175.

The present paper is the outcome of a suggestion by Professor Woolnough given in the course of lectures, and the writer desires to tender his best thanks to Professor Woolnough for much kind help and many suggestions.

Principal Units in the Physiography of Perth Area.

The most striking feature of the country round Perth is the well marked Swan Coastal Plain. It is bounded on the east by a fault escarpment, the fault dividing the plain from the so-called "Darling Ranges." A better name is, as suggested by Jutson, the Darling Peneplain. The sea borders the plain on the west. It is very level throughout, only near the coast does it reach an elevation of 200 feet. The surface rock is entirely recent, right from the foothill of the escarpment to the coast. This applies more particularly to the Perth area; at Gingin cretaceous rocks have made their appearance. Starting at the fault and going westwards, sand is the commonest soil, with no hard rock outcropping. This is interbedded with alluvials of the various rivers which rise in the hills: the brickmaking clays from Bellevue to Guildford are examples of these alluvials. The sand is well shown in section in any of the railway cuttings between West Subiaco and West Guildford. The soil is grey, and the subsoil yellow, no solid rock appearing at all.

Further west a distinct belt can be recognised. It is characterised by the presence of abundant concretionary travertine in the superficial layers. The travertine always overlies æolian sandstone, and the lime of the travertine has certainly been derived from the sandstone by the agency of underground water in the manner described by Simpson for the origin of laterite.*

Forming the actual seashore are very recent dunes, composed of loose drifting sand, in which no cementation has taken place at all. Further inland, and often partially submerged by the new ones, is an older series of dunes: notable members are Buckland Hill and the larger hills around Fremantle. The railway cuts several between Cottesloe Beach and North Fremantle stations. The surface of these hills is always covered with the usual irregular travertine. Below this is the sand or friable sandstone, which is usually strongly current-bedded. Near the surface this sandstone contains many roots which have usually been encased by concretionary calcium carbonate. In the cuttings and quarries, the soft sandstone

* Simpson, E. S. "Laterite in Western Australia," Geol. Mag., 1912, p. 400.

has been weathered away from around these roots, which stand out in consequence. Mount Eliza lies well outside this belt, but exhibits all the characteristics just enumerated, and therefore may be a remnant of an earlier series of dunes lying further inland. These dunes offer comparatively little resistance to forces of erosion, being composed of a partially soluble rock (sand grains cemented with calcium carbonate), and therefore they would be rapidly removed from the landscape. Possibly by reason of its size or of some other factor affecting the rate of erosion, Mount Eliza should be the last of this series of dunes to disappear and merge into the general sandy formation of the district. The same remarks apply essentially to Mount Henry on the Canning River.

Evidences of Extensive Subsidence.

Many bores have been put down in the area, and they show rocks of the same type as those above described—alluvial, sand, etc., for a depth of 2,000 feet at least. The area is therefore one of extensive subsidence. The physiography of the Swan River also confirms this, because of its evident drowned character. This feature of the Swan River has been repeatedly noticed in the literature of the subject. Therefore, for some considerable time past, the Swan Coastal Plain has been subjected to a dominant downward movement.*

Physiographic Elements in the Lower Swan Valley.

The Swan River can be divided into two distinct parts:—

(1.) The section extending from Fremantle to the Causeway, in which the phenomena of a drowned valley are very distinct; and

(2.) The rest of its course, in which the normal features of river development are dominant. This part has not suffered to any marked extent from the drowning of the first part.

The drowned part can be again divided into two sections: (1) from Fremantle to Point Walter on one bank, and Claremont on the other, and (2) from these points onwards to the Causeway. In the lower section, from Fremantle to Claremont, the banks of the river are mainly lined with cliffs, and the river itself is narrow and of uniform width; whereas in the upper section, from Claremont to Perth, low shores and shelving beaches are the rule, and also the banks recede in places, resulting in the formation of broad "waters" and promontories.

*For fuller discussion of this subject see Jutson, J. T., Miscellaneous Report 30, Bull. No. 48, W.A., Geol. Surv., and Jutson, J. T., Physiography of Western Australia, Bull. No. 61, W A., Geol. Surv.

Evidence of a Small Superimposed Movement of Elevation.

Very recently there has been a slight elevation superimposed on the general subsidence. The evidence is supplied by raised beaches, which are common enough round the shores of the Lower Swan and on the neighbouring ocean beaches. These raised beaches are of several different types:—

(1.) *Shell Beds.*—These are bands of incoherent sandstone thickly crowded with shells, all of which are closely allied to, if not identical with living forms in the neighbouring waters. Several such bands may be seen in a single section, separated by layers of normal sandstone. By reason of their form and origin (which will be dealt with later) the amount that they have been uplifted can be readily measured. The highest bed of this type is the highest raised beach of the area, and is 22 feet above high water mark.

(2.) *Beach Breccias.*—These structures in a consolidated form are often associated with shell beds. The rock fragments, of which they are composed, were perhaps derived from rocky points or headlands rising from the beach.

(3.) *Uplifted "Spits."*—A different type of raised beach is illustrated by the "Spit" of the Swan River. A normal "spit" has certain well marked characters which are easily recognised when it has been uplifted.

(4.) *Beach Platforms associated with Uplifted "Spits."*—The "spit" often merges on its flanks into narrow beaches or platforms. These are generally found at the foot of a cliff, and range in width from 5 to 30 or 40 feet. Such beaches can be recognised not only at present river level but also in considerably uplifted positions.

(5.) *Wave-cut Platforms.*—Wave-cut or marine platforms are common on the ocean beaches of the area, and show varying amounts of uplift.

Details of the Raised Beach Structures.

(1.) *Shell Beds.*

There are very numerous occurrences of the shell beds, some are shown in natural section such as cliffs, and others have been exposed by artificial means in quarries, etc. In an earlier section of this paper the physiographic elements of the Lower Swan Valley were dealt with and a section of the river from Fremantle to Claremont was differentiated from the rest. This is the only part of the river in which outcrops of shell beds are known to occur. This fact probably has an interesting bearing on the physiography of the Swan River.

At about the centre of this lower part of the Swan is *Minim Cove* (A on map), and here an interesting series of beds occur in a cliff section. The shell beds are horizontally stratified bands lying conformably with sandstone above and below. Each band is

crowded with shells in a matrix of very friable sandstone. In some cases the sand is entirely unconsolidated. The shells are mainly lamellibranchs, usually with their two valves united as in life, the interior being filled with sand and shell débris. These bands alternate with sands from below low water mark to a height of 16 feet above high water mark. The beds attain a maximum thickness of 2 feet and their distance apart is of the same order. Of course the sand and shellbeds merge into one another, there being nothing in the nature of a sharp line of demarcation between the two. About two or three chains down the river bank another bed makes its appearance; it is only two or three inches wide but is quite horizontal and is of a similar nature to the wide bands below it. This bed is the highest met with at this place and is 17 feet above high water mark. It is covered by over 20 feet of dune sandstone, which is current-bedded and of typical dune origin. Evidently after the formation of this highest bed, sand dunes had advanced and obliterated the beach.

At *Hinemoa Rock* (B on map) a shell bed outcrops in the face of the cliff there. It is very similar to those at Minim Cove. It is 15 feet 6 inches above high water mark and there are 4 or 5 feet of sandstone above it. At Peppermint Grove (C on map) similar beds outcrop in the cliff faces. They show an uplift of 19 feet. There are several of them outcropping, and one merges into a beach breccia, which contains rounded fragments of large shells. This will be referred to later.

Near the jetty at Mosman's Bay (D on map) excavation has disclosed a shell bed. It is approximately 10 feet above high water mark. The assemblage of shells here is slightly different from that at Peppermint Grove and altogether different from that at Minim Cove.

There is an interesting section at "The Coombe" (E) between Mosman's Bay and Hinemoa Rock. Two beds are seen here but they are not horizontal. The lower one is a typical shell grit mixed with sand. There are few whole shells and these are of robust make, able to stand the buffeting of waves on a shore. At the north end this bed slopes upwards more steeply and changes in character. The shell fragments become larger and are smoothed and polished. Among them are limestone pebbles, and at the bottom of the bed these increase in number and the beds merge into a limestone breccia. These two structures adjoin a mass of rock which was certainly in the nature of a rocky point on the beach. On top of this rock a few shells are scattered and these are similar to those above the breccia. This rocky mass is of bedded sandstone and is coated with a layer of travertine in places. The sandstone shows curiously contorted laminæ in several places. They are folded fairly simply and the best explanation of this seems to be that they are caused by the slipping of an original quicksand, due to some

inequality of pressure. The nature of the shell bed and the presence of water-worn shells and pebbles point to the conclusion that here we have an original ocean beach with a rocky point, flanked by sand which overlies a beach breccia of limestone. A considerable quantity of shell grit was strewn over the beach, the whole structure thus resembling exactly a common present-day type of occurrence. Above this formation is more sandstone until another shell bed is met with at about 20 feet above high water mark. This bed also slopes upwards towards the north end. It is about 1 foot in thickness and the shell composition approaches that of the Minim Cove beds, and has little in common with the other bed immediately below. The north end of this higher bed is 23 feet above high water mark. This is the highest raised beach that has so far been found and therefore 23 feet is the greatest ascertained uplift.

In *Blackwall Reach* and on the right bank of the river there is a conspicuous cliff (F), and there is good evidence of uplift here. About 20 feet above high water mark and in a particular part of the cliff is a formation that is somewhat like a wave-cut platform and is overlain with beach sand and shells. Immediately below the 20-foot level the rock is a fine-grained solid limestone, merging further down into sandstone. The upper surface of this limestone is remarkably level over a considerable area. This is altogether unlike the normal travertine surface, which is characterised by sharp pinnacles of travertine or "niggerheads," due primarily to weathering. Above the 20-foot level and lying on this flat limestone surface is a very coarse sandy grit. This grit has a few smooth shell fragments in it, which, however, are broken up so that recognition of the species is quite impossible. There is a thickness of about 2 feet of this grit whose position agrees closely with that of the uplifted shell bank on the other side of the river.

Above this raised beach is about 6 feet of æolian sand covered with travertine. There can be no doubt that this was an ocean, and not a river beach, for the grit is very coarse (many grains are .4 cm. in diameter). They are quite rounded and smooth, as are also the shell fragments present. Some of these latter are much larger, being 5 or 6 cm. in their greatest dimension. The individual sand grains are mainly of quartz, though a large percentage are calcareous and of organic origin.

Other occurrences of raised shell beds have been recognised on the ocean beach between Fremantle and Cottesloe, and also at Rottnest Island.

There are three rocky points on the beach between Fremantle and Cottesloe, the first is at the *Cable House, Cottesloe Beach* (G), the second, at the *Bathing Sheds, Cottesloe Beach* (H), and the third is at the *Cottesloe Jetty* (J). At the Cable House the bed is a shelly, sandy limestone, the relative proportions of shells, sand, and secondary calcium carbonate varying between wide limits. The

rock is generally fairly hard and well cemented. This bed is only a little above high water mark, being barely out of reach of the winter storms, but is 5 or 6 feet above ordinary summer high tide mark. This bed is on top of a wave-cut platform which will be mentioned later. At the bathing sheds, Cottesloe Beach (H) an exactly similar bed occurs, being of the same composition and is about the same height. At Cottesloe Jetty (J) numerous shells are to be found in the rock there up to a height of about 10 feet in places. These shells are rather sparsely shattered in the sandstone but they definitely indicate that originally the latter was beach sand.

At *Rottnest Island* only a small portion of the ocean beach has been examined—that part from the main settlement to the west point of the bathing pool; but abundant and clear evidence of uplift is available even in this restricted area. At the west point of the bathing pool is a bed of sand and shell which shows a clear uplift of 5 feet above the highest tide mark. The material consists of round and smoothed pebbles of rock, of coarse sand, and of round smooth fragments of shells, which are varieties identical with those on the present day beaches. The whole mass is entirely unconsolidated and is overlain directly by dune sand. Noteworthy here also is the occurrence of ripple-marked sandstone, a structure which, for some reason, is rather rare in the area under consideration. In the present instance it does not appear to have been very definitely uplifted.

Below the lighthouse is another unconsolidated beach rubble, containing large shell fragments and this has been uplifted to about 10 feet above high water mark.

This completes the list of the more important occurrences of the beds so far examined. They are roughly of two types; the first type is a conglomerate or grit containing large or smooth fragments of big shells, such as would resist the battering action of the surf. This type is exemplified in the raised beaches of Rottnest Island, at the cliff in Blackwall Reach (F), at "The Coombe," (E), and at Peppermint Grove (C). The most robust and typical shell in these conglomerates and grits is Arca, which is an ocean type. The other type of shell bed is met with most typically at Minim Cove (A). The highest bed at "The Coombe" is of this type, as also are the beds at Peppermint Grove and Mosman's Bay. In these beds many of the pelecypods have the two valves united as in life, showing that these beds were beaches, comparatively undisturbed by heavy surf. At the same time shells such as Pinna and many gastropods have been washed up on to the shore, on top of the living lamellibranchs. It is noteworthy that a very perfect quartz crystal of the typical prismatic form, about 1.5 cms. in length, has been found in these beds at Minim Cove. The relative proportions of lamellibranchs, whose shells are still in the original position of growth, decrease considerably as we pass from the

Minim Cove beds to the beds at "The Coombe," Mosman's Bay, and Peppermint Grove, the decrease being in the order mentioned. Perhaps this shows that the beach was more sheltered at the Minim Cove end than towards Peppermint Grove.

(2.) *Beach Breccias.*

These are often connected with, and merge into, the shell beds, and thus have been described in part above. At "The Coombe" the breccia is of travertine mainly, though some sandstone fragments occur also. They are bound in a matrix of smooth-grained sand and the whole cemented with secondary calcium carbonate. At "The Coombe," and still more so at Peppermint Grove, there are some conspicuous black or brown limestone pebbles. Such dark-coloured limestone is unknown to the writer in the Perth District, but subsequently a macroscopically and microscopically similar rock was found in the limestone cliff at Deepdene, near Karridale, in the South-West of this State. There, it occurred as a vein in the limestone, and possibly the black limestone in the breccias had a similar origin. Fragments of shells are common in these breccias, which have been formed by wave attack on small cliffs and projecting rock.

(3.) *Uplifted "Spits."*

(4.) *Beach Platforms associated with Uplifted "Spits."*

These two subjects are closely related and it will be well to consider them conjointly. So-called "spits" are very common in the drowned part of the Swan River. The most typical one is at Point Walter. The main characters are a more or less pronounced headland, stretching out from which is a long narrow bank of sand. The bottom is fairly shelving at the sides, but at the end it drops down suddenly to deep water. The level of the sand is, unless disturbed by later currents, at the level of low water from the shore end to the extreme point.

The *South Perth Raised Spit.*—At South Perth, Mill Point more exactly, the evidence of uplift is very clear. All the essential structures are preserved. The Mill Point jetty is a very short one, but the end of it is in deep water. The road leading back from the jetty is level for a considerable stretch and then at Mends Street rapidly rises up a hill. The level stretch corresponds with the originally submerged sand spit and the hill is the original headland, having been dry land when the spit had not been uplifted.

The *Crawley-Nedlands Spit.*—Here the evidence is more complicated. The original spit was large and possibly it has been added to after uplift. On reference to the contour map (Plate II.) it can be seen that the contours, especially near the tramway, begin to close at about the 20-feet level. The land is gently rising up to

about the 20-foot contour and then the slope is increased, indicating a bank or original headland. This bank is somewhat broken in the neighbourhood of Ferdinand Street, but reappears further north and merges into the cliffs bordering the Perth-Fremantle road all the way to Perth. To the south the bank or headland merges into another cliff south of Nedlands. The flat area is narrow at the foot of both these cliffs and broadens west of Pelican Point. It is evident that here we have reproduced the characteristic form of a spit in an uplifted position. Low tide mark in a normal spit is just at the foot of the headland, and as far as can be judged by contour maps and inspection of the ground, the original low water mark is the present 20-foot contour. This indicates an uplift of 20 feet approximtaely.

At Crawley, in addition, a true spit is developed at the end of the uplifted one, either by accumulation of material since the uplift took place, or possibly by wave erosion. The waves of the river caused by the powerful "Fremantle Doctor," the sea breeze of the summer, and by the winter gales, would be quite competent to reduce the land by erosion, and to bring its surface to low tide mark, thus producing an ordinary spit. This process can be studied at the present day. The end of Pelican Point consists of a small bank two or three feet high. The foot of this is washed by high tide, and the sand is being worked downwards and outwards to at least below high tide mark.

Peppermint Grove.—There seems to have been a large uplift here. Probably Butler's Hump was originally a rocky mass joined to the mainland by a spit and a broad shelving beach. On uplift the whole was left dry and shows a narrow ridge on the river end, widening to a broad platform. The ridge and platform are approximately 12 feet above high tide mark.

Points Roe and Preston.—Typical spits are not developed here but different structures have been raised. Before uplift these were roughly triangular areas of shallow water, the sandy bottom being somewhat lower than low water mark. They were bounded on the land side by a steep abrupt headland. At both places this structure has been uplifted, forming a flat area of ground, but a few feet above water level. At the present time the same structure is being formed at the end of the old one. At Preston Point the contour map indicates an uplift of about 10 feet by an application of the same principles as were used in the case of the Crawley-Nedlands raised spit.

A structure similar to that found at Point Preston is seen at *Augusta*, on the mouth of the Blackwood River, and would doubtless be found at the mouths of many rivers and drowned valleys round the coast. At Augusta the flat upraised shallows are well shown on the same side of the river (a drowned valley here) as the settlement and between the latter and the actual mouth. These shallows are

here also continued into the water and end in a very sudden dip similar to that at the end of the Point Walter spit in the Swan. The uplift is of the same order of magnitude at Augusta as elsewhere.

At two places, at the Crawley-Nedlands Spit and at Point Preston, the uplifted areas grade from the type already described to a narrow platform running round the base of a cliff. This platform seems to have been a shelving beach in such a position that at high tide the waves washed the foot of the cliff. At Crawley this platform carries the Mount's Bay Road right round to the Esplanade. At Preston Point also the platform carries a road.

When the fact of an uplift has been established by other independent evidence it becomes easy to recognise uplifted structures. The flats around the Causeway are thus easily and readily explained and a similar remark applies to the flat at Augusta just mentioned. The characteristics of a typical occurrence are as follows:— (1) An almost perfectly flat area of land a little above water level. (2) This is bounded landwards by a steeply rising bank. (3) Towards the river there is a similar steep drop. In many cases this steep drop on the river side is not met with near the shore, shallow water may extend outwards for some distance, perhaps as much as a hundred yards from the shore. That is to say, the land surface shelves gradually from slightly above water level to slightly below it. Generally speaking this result may be caused either by an incomplete uplift of the spit or by a new sand bank being built up on the end of the old one. If a partially uplifted bank had originally a slight slope from the inner edge down to the outer edge, then the rise and fall of the river, due to tide or flood and the action of waves, would tend to degrade that portion of the land surface affected by these agents, and this would cause the formation of a wave-cut bank; it may be only a few feet high, at the high water mark. Examples are seen on the Crawley-Nedlands spit (Point Pelican), at Point Walter (near the land end of the jetty), and at many other places on the Swan, and also at Augusta.

Analogous structures on a large scale are seen on the Swan, particularly at the raised spit at South Perth and at Point Walter. They constitute the second characteristic of raised spits. The formation of these would be quite analogous to the smaller structures mentioned, for on the drowning of the Swan Valley, the new water level would often come part of the way up a sloping surface and the river would proceed to cut into the sloping bank by the action of waves and tide.

It is only necessary to mention other examples of raised platforms, spits, etc. They abound round the shores of the Swan up to the Causeway. Many of these upraised areas are shown in black on the map of the area. Near the two bridges at Fremantle are

extensive raised areas. An excellent example of a raised platform occurs near Nedlands and the old Men's Retreat. At Applecross a broad platform has been formed by river action.

(5.) *Wave-cut Platforms.*

There is still another class of phenomena showing the result of this recent epirogenic movement: the wave-cut platforms. The most perfect examples of these structures are to be seen at Rottnest Island. Near the settlement is a platform upwards of 100 yards in width. It consists of a flat surface of rock (sandstone and limestone) extending outwards from the shore and ending abruptly in deep water. These structures shelve very gradually, if at all, from the shore outwards. They are formed by wave attack, and thus the rocks of the land are reduced to the lowest level of effective wave action. This would certainly be well below low water mark. The erosion of a platform by waves would be faster between low and high water mark than it would at high tide mark itself, because the waves are acting for a longer time on the former portion. Consequently, it is probable that, in a platform of moderate width, the outer edge should be worn down to the lower limit of fast wave action, *i.e.*, low tide mark. Below low tide level the wave action is slower, because breaking surf is a faster abrading agent than the more slowly moving water we have below the low tide level down to the lower level of effective wave action. On many of the wave-cut platforms along the coast, particularly at the Cable House (G), and at Cottesloe (J), the outer edge of the platforms is being actively attacked, as is evidenced by the surf usually breaking there. It is therefore a fair assumption that these platforms have been slightly uplifted and they are therefore in the course of being planed down again. In two places, however, at the Cable House (G), and at the Bathing Sheds, Cottesloe Beach (H), platforms have been raised to more elevated positions. They are now recognised by residuals, in the form of a narrow shelf, a few feet higher than the present platform. These higher platforms are best seen in the winter time, in the summer they are partly hidden by sand.

Summary of Conclusion.

Superimposed on the extensive and universally recognised cycle of subsidence which impressed upon the Swan River Valley its characteristic features there has been a movement of elevation, amounting to at least about 23 feet. The evidences for this are as follows:—

(1.) In the vicinity of Cottesloe and North Fremantle there are numerous occurrences of *Shell Beds*, at heights above high water mark ranging up to 23 feet approximately.

(2.) Associated with these shell beds are *Beach Conglomerates* or *Breccias* having similar occurrences and significances.

(3.) On the shores of the lower part of the Swan River certain physiographic forms are recognised, described, and claimed to be uplifted spits. By a comparison with present day spits the amount of their uplift has been obtained approximately.

(4.) *Beach Platforms* also occur on the shores of the lower Swan River. They are often uplifted and the amount is easily determined by means of a comparison with the structure before uplift.

(5.) On the ocean beach between Cottesloe and North Fremantle *wave-cut platforms occur* which are shown to have been uplifted. The amount of uplift is rather indeterminate, but is of a small order of magnitude.

The shell beds are met with chiefly on that part of the Swan River lying between Claremont and Fremantle. It is shown that this section of the river is structurally distinct from the portion between Point Walter and the Causeway. The significance of this difference will be discussed in a later paper.

The mode of origin of the uplifted structures in process of formation in the river at the present time is discussed. Similar evidence of elevation at Rottnest Island and at Augusta is given.

Plate I.

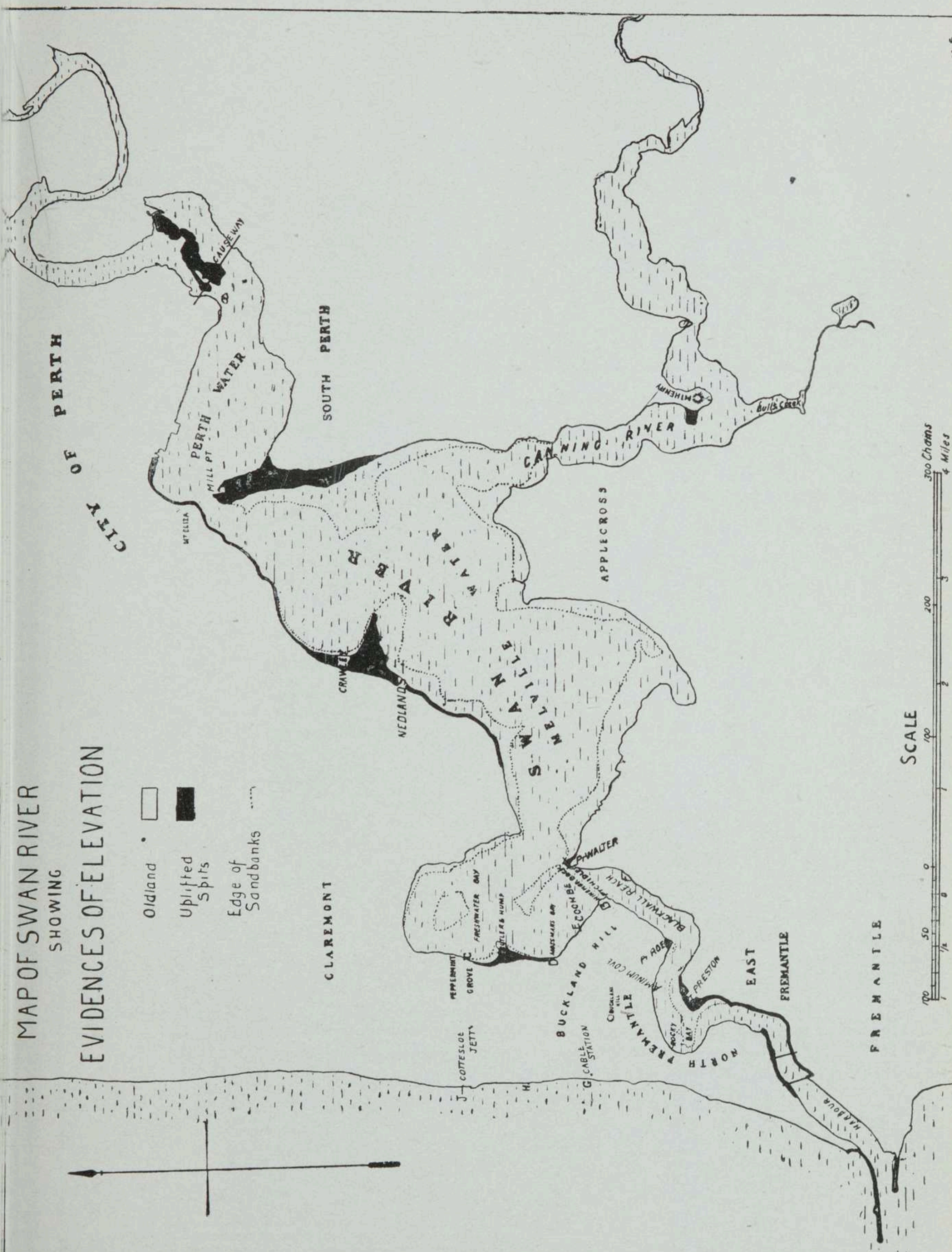
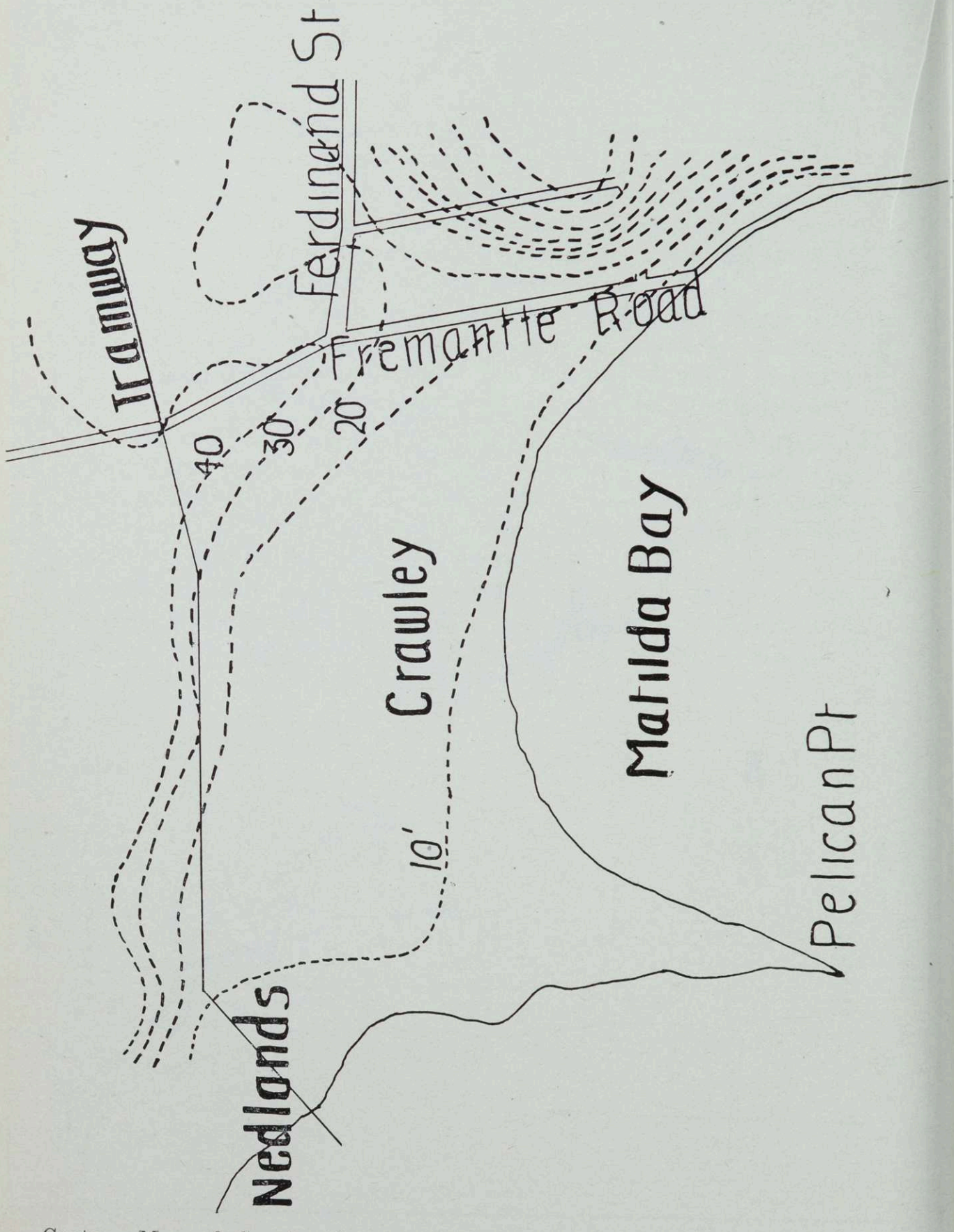
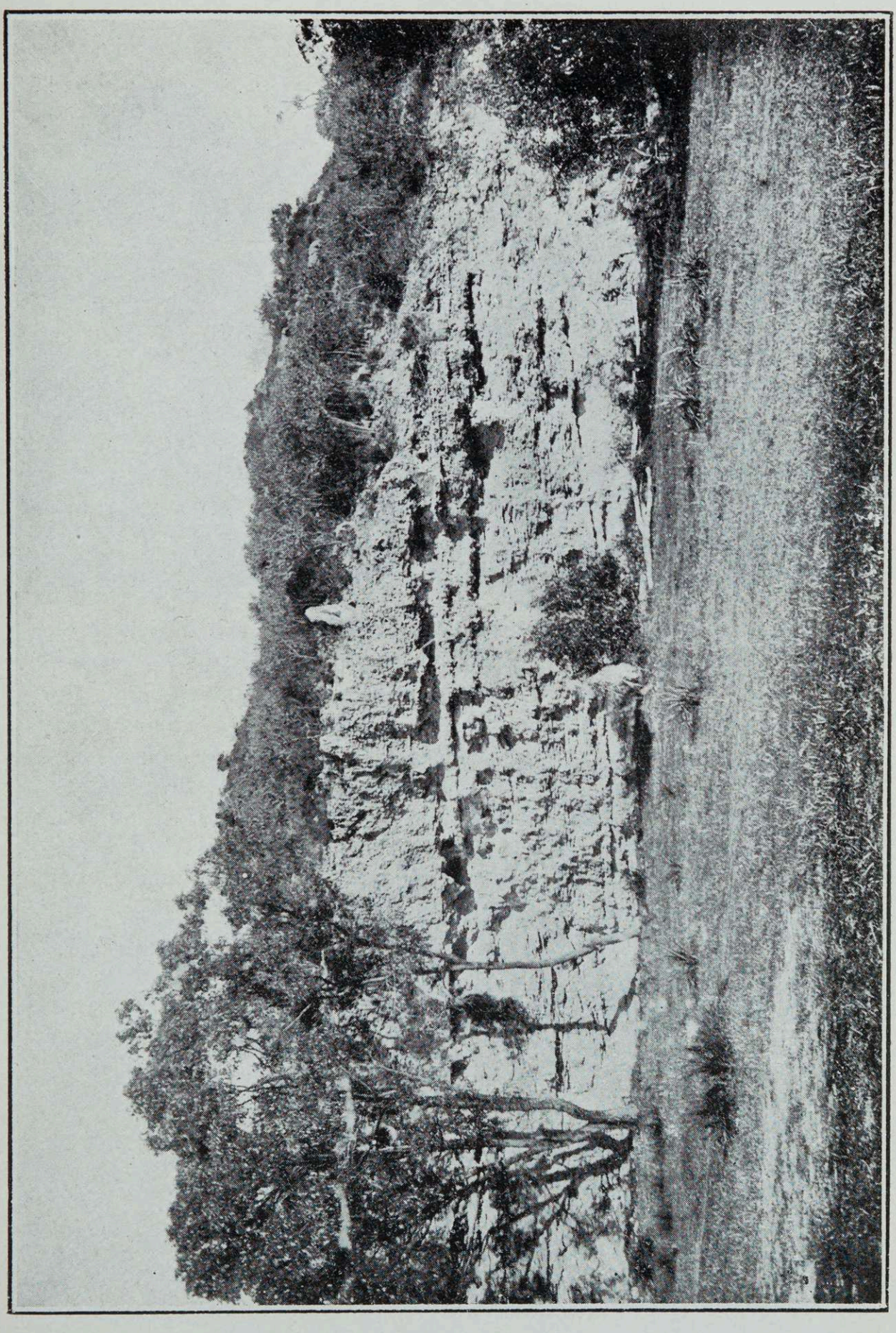

MAP OF SWAN RIVER
SHOWING
EVIDENCES OF ELEVATION
Oldland
Uplifted Spits
Edge of Sandbanks
CITY OF PERTH
PERTH WATER
SOUTH PERTH
CAUSEWAY
MILL PT
CANNING RIVER
Bull's Creek
APPLECROSS
SWAN RIVER
MELVILLE WATER
NEDLANDS
CRAWLEY
CLAREMONT
BUCKLAND HILL
COTTESLOE JETTY
CABLE STATION
PT WALTER
BLACKWALL REACH
PRESTON
EAST FREMANTLE
NORTH FREMANTLE
FREMANTLE
HARBOUR
SCALE
300 Chains
4 Miles
J.L.S.

Plate II.



Contour Map of Crawley-Nedlands Spit, showing evidence of elevation.

Plate III.

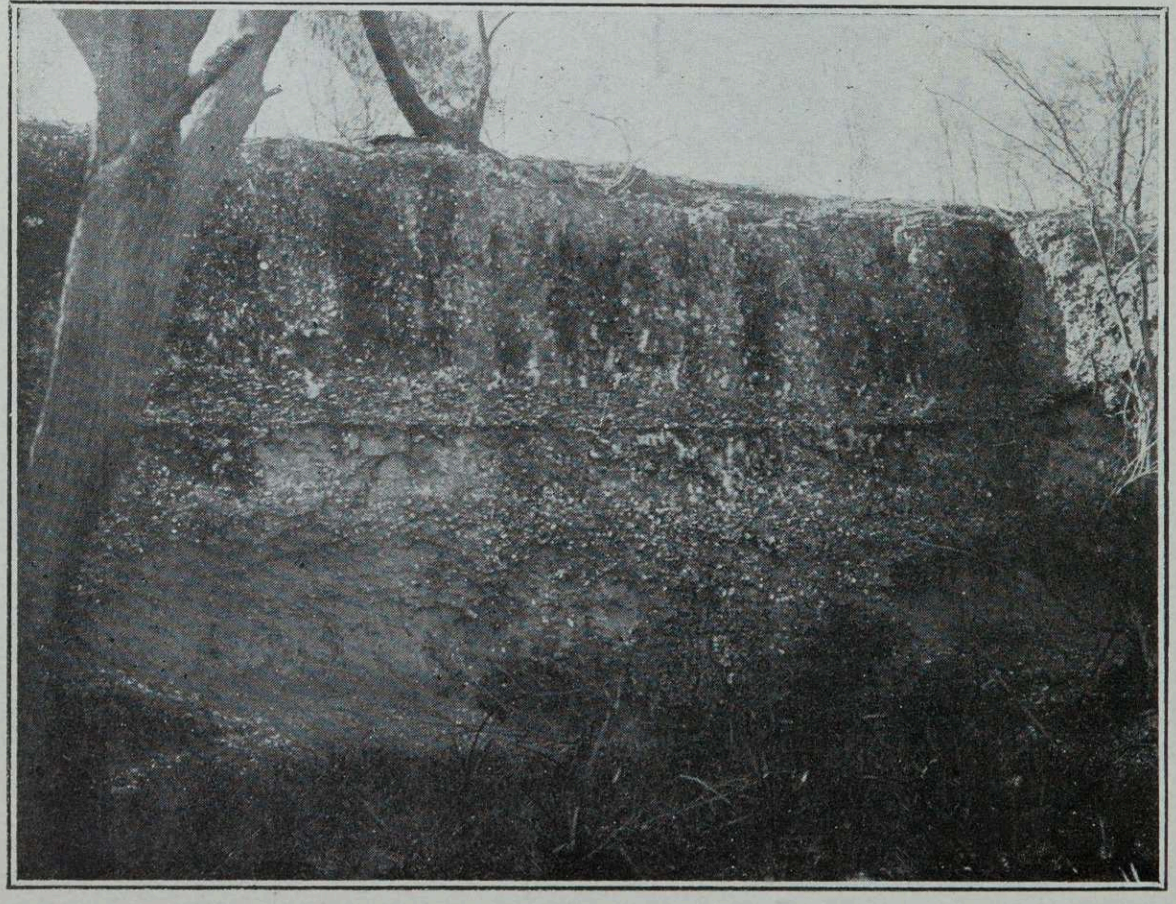


Cliff section at "The Coombe." Two well marked, roughly parallel lines can be seen in the cliff face. The upper one is the higher of two shell beds, and rises slightly to the north. The lower line is the other shell bed. To the left (south) it sinks below the ground level. To the north it rises and there overlies a structure interpreted as a rocky mass on the original beach.

Plate IV.

Upraised Spit at Point Roe. On the right is the sandy flat which was the original sand bank, and on the left is the steep bank, the original headland.

Plate V.



Cliff section at Minim Cove. Shows two well marked shell beds. The whole of the sandstone composing the beds contains numbers of shells.